



# Yann H. Kerr

## CESBIO

Yhk-2008

Microwave RS for Land Hydrology –  
Oxnard Ca USA



# Outline

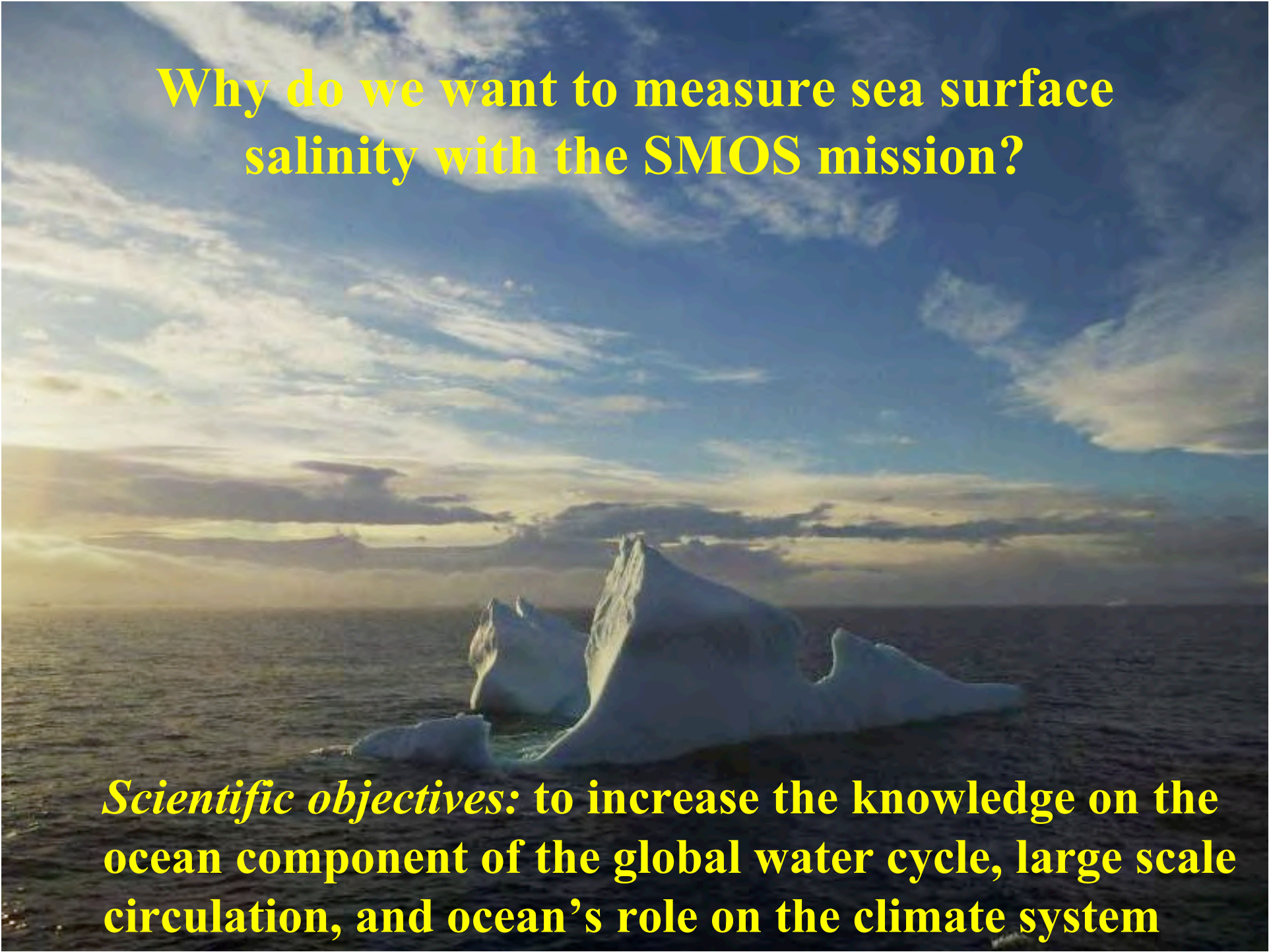
- General overview
- A long International Story  
Interleaved with:
- The SMOS project
  - Status
- Conclusion



# Why measuring Soil moisture?

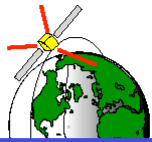
**Scientific Objectives:** Improve our understanding of the land component of the global hydrologic cycle, of the spatial and temporal evolution of the water storage, and of the soil atmosphere interactions so as to improve **global water resources management - globally.**



A large, jagged iceberg floats in the dark, choppy ocean. The sky is a deep blue with wispy white clouds, and a warm, golden light from the low sun on the horizon illuminates the scene, creating a dramatic atmosphere. The iceberg's surface is uneven, with sharp peaks and deep crevices.

# **Why do we want to measure sea surface salinity with the SMOS mission?**

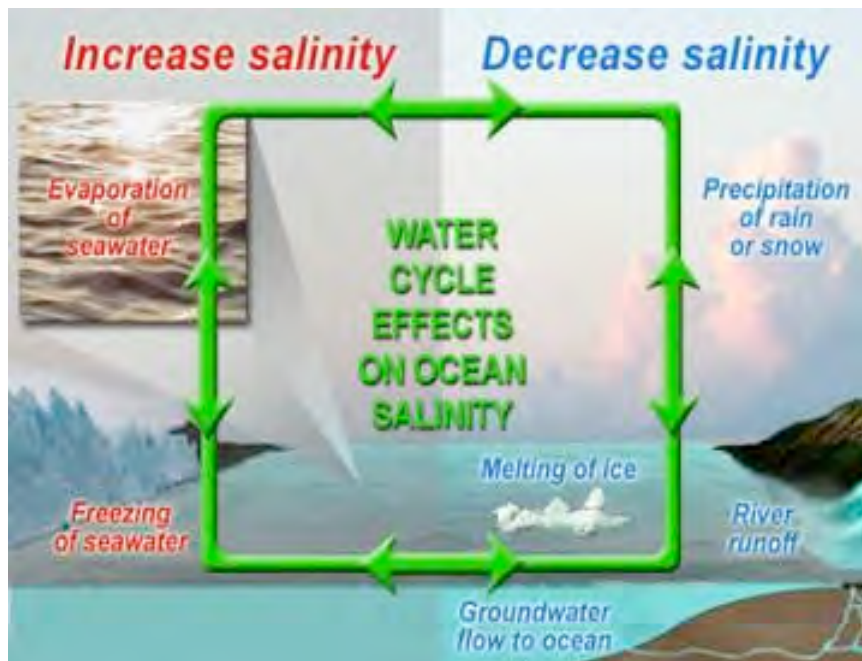
***Scientific objectives:* to increase the knowledge on the ocean component of the global water cycle, large scale circulation, and ocean's role on the climate system**



# Ocean Salinity and Climate

Salinity links the climatic variations of the global water cycle and ocean circulation

- Salinity is required to determine seawater density, which in turn governs ocean circulation.
- Salinity variations are governed by freshwater fluxes due to precipitation, evaporation, runoff and the freezing and melting of ice.



## Air-Sea Water Flux accounts for

- *86% of global evaporation*
- *78% of global precipitation*

## Importance

- *Climate prediction*
- *El Niño forecasts*
- *Global Water budget*

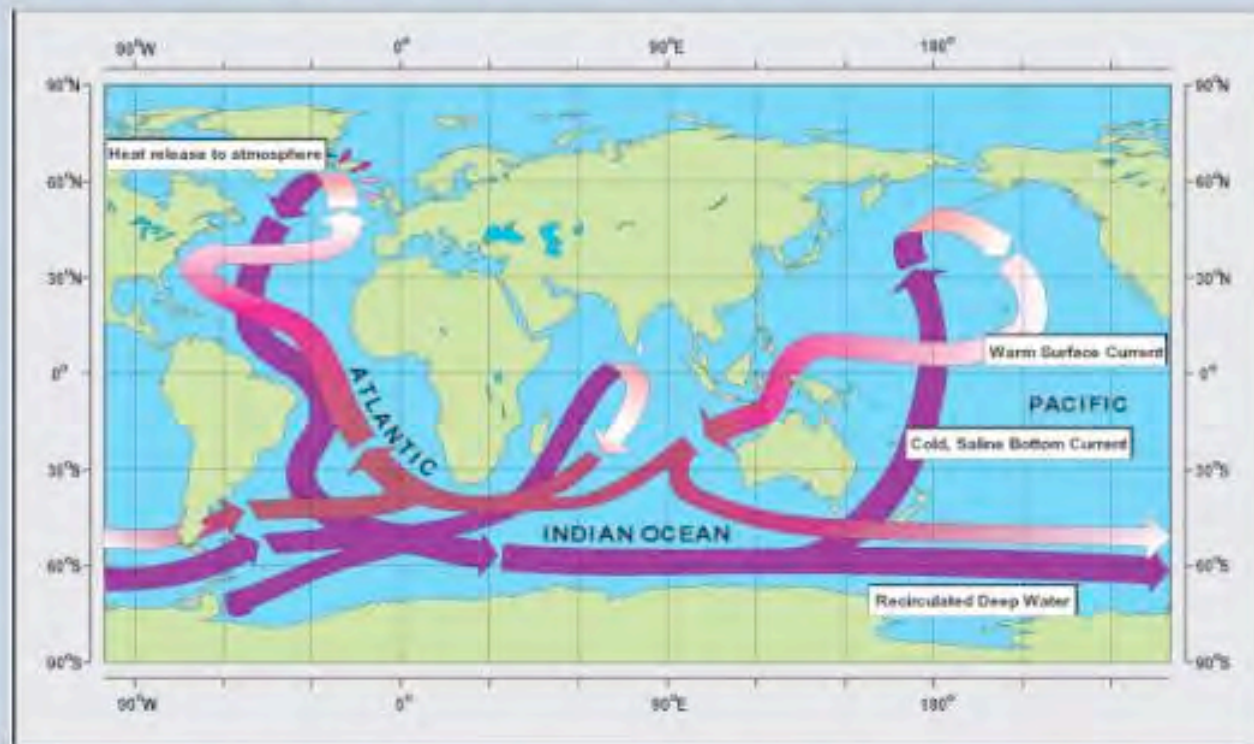


# Salinity and Ocean Circulation

The ocean conveyor is sustained by elevated salinity in the Atlantic

## The Atlantic Thermohaline Circulation

- A key Element of the Global Oceanic Circulation -



Schematic diagram of the global ocean circulation pathways, the 'conveyor' belt (after W. Broecker, modified by E. Maier-Reimer).

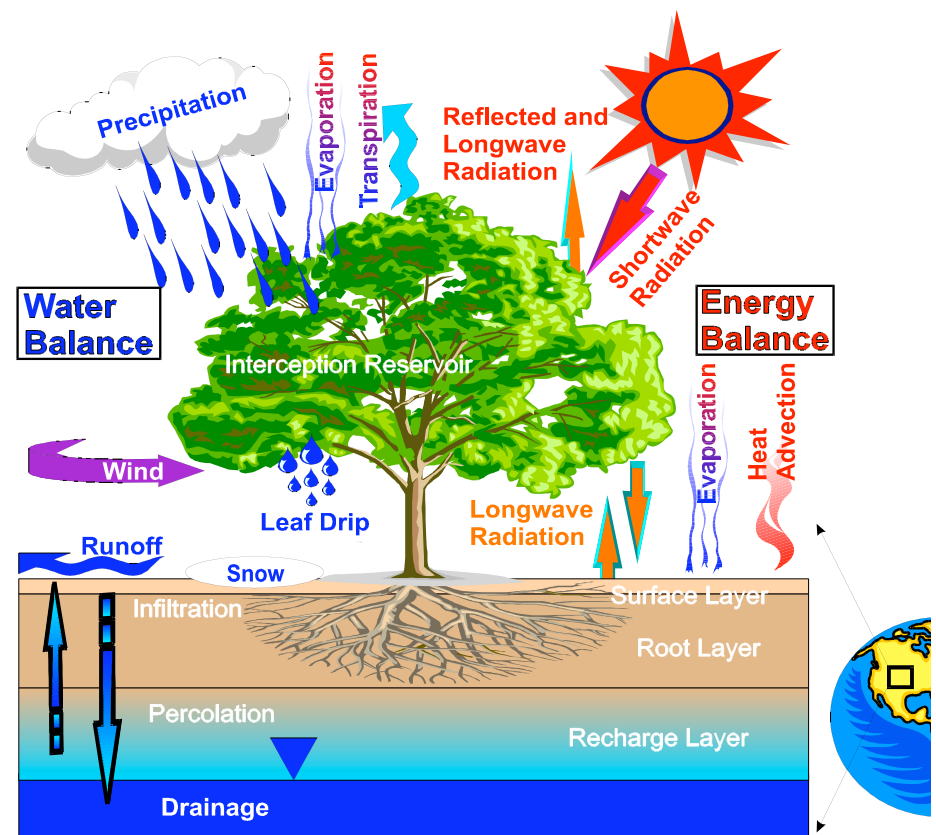
AV/D3/99-2

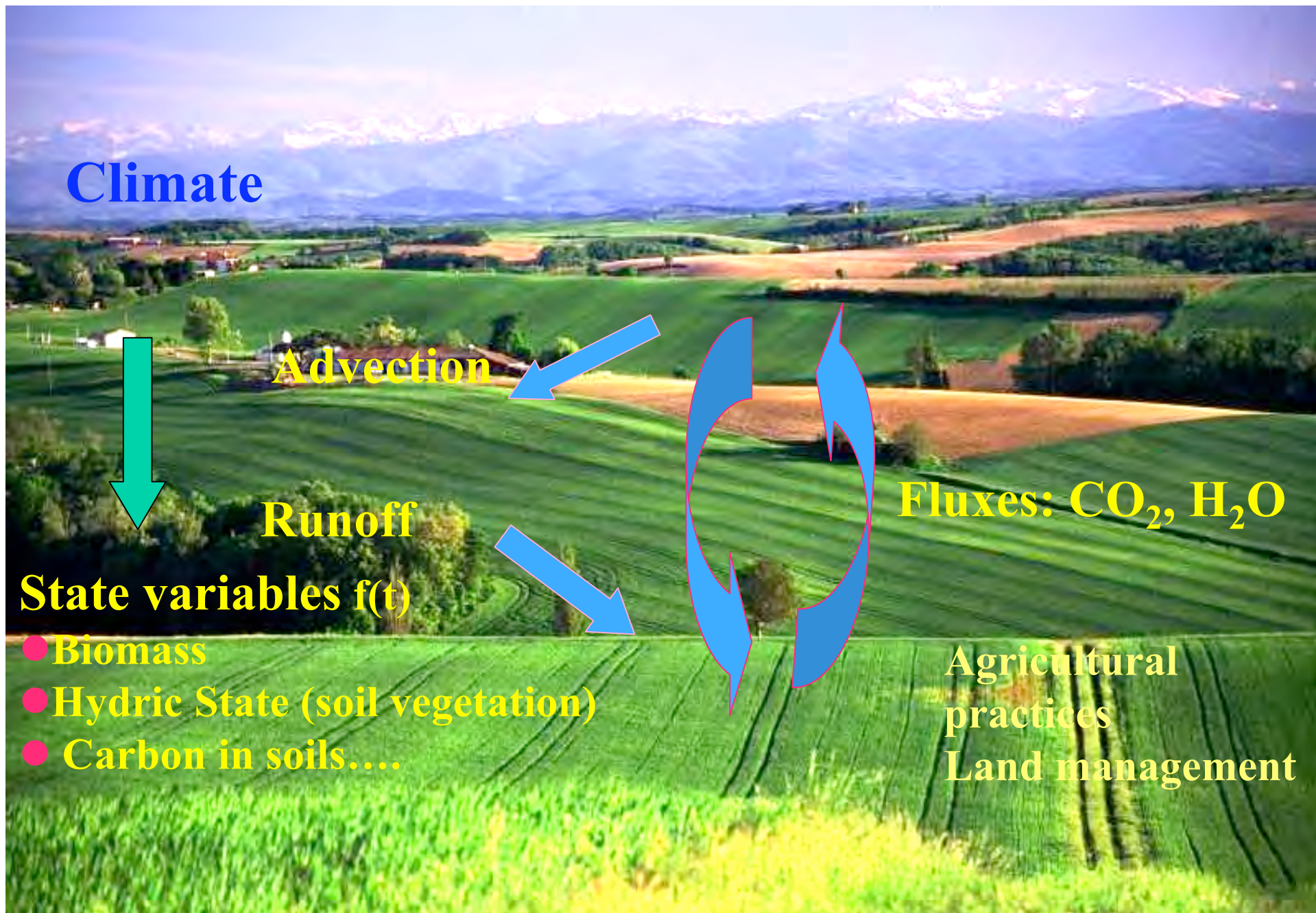




# SM Rationale

- Role of Soil moisture in surface atmosphere interactions:
  - storage of water (surface and root zone), water uptake by vegetation (root zone), fluxes at the interface (evaporation), influence on run-off
- Implies relevance for
  - Weather Forecasts
  - Climatic studies
  - Water resources
  - crop management
  - Forecast of extreme events







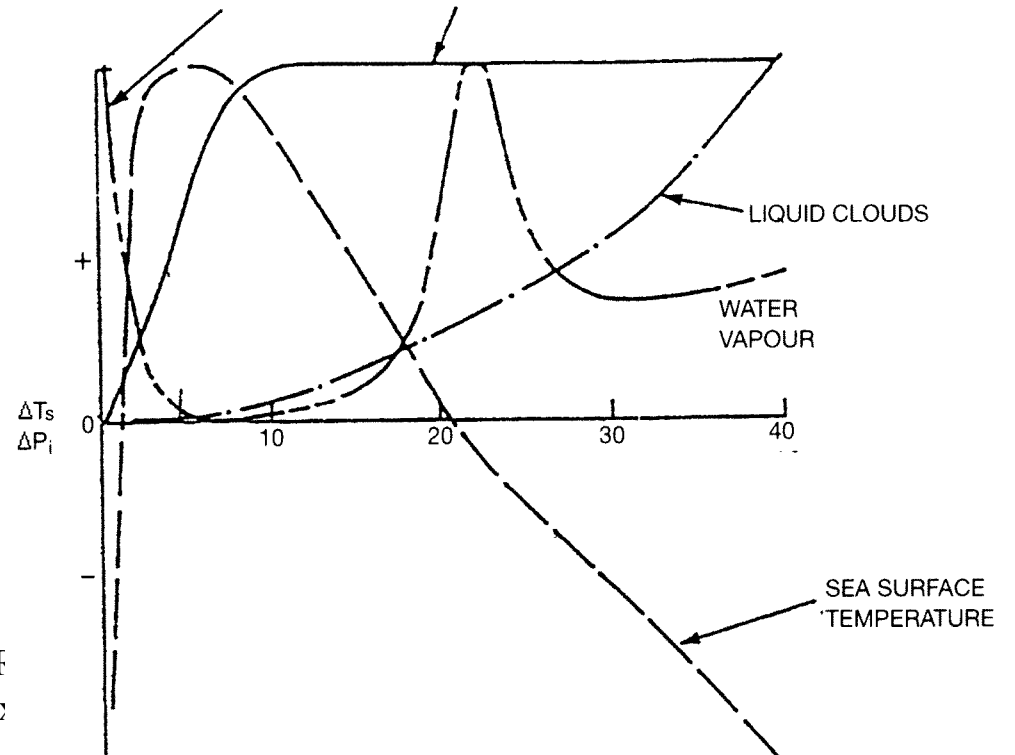
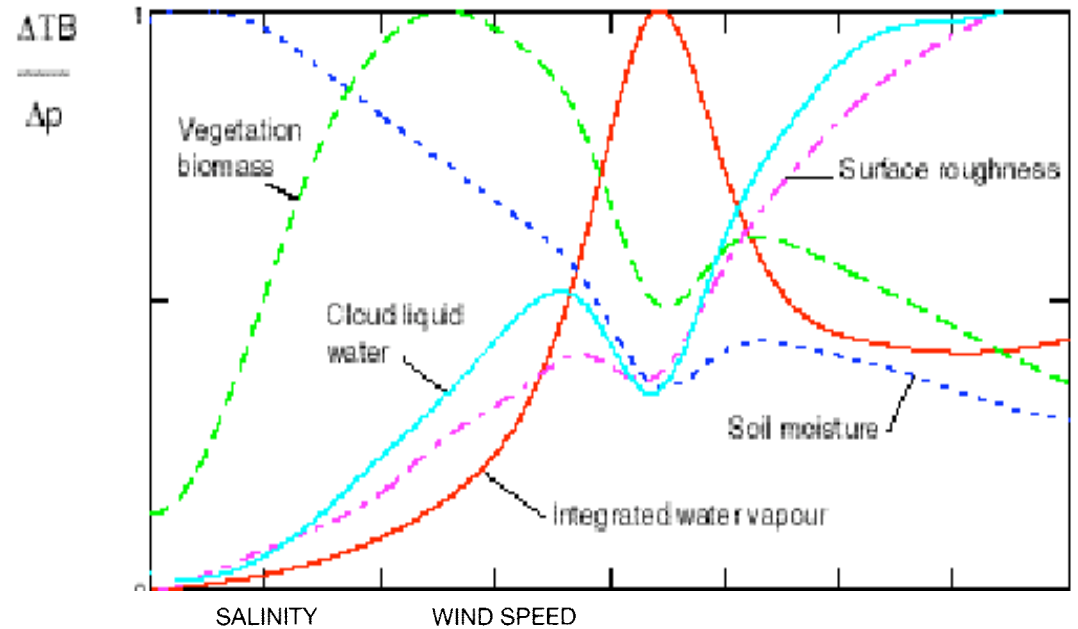


# Rationale

- Changing climate
- Extreme events (floods, droughts, storms...)
- Water management
- Adequation of crops and cultural practices to forcings
- ➔ requires better forecasting and decision making tools
- need for SSS and SM frequent and global fields



- Passive microwaves
- L Band
- Antenna size → Two concepts
  - Aquarius/ SMAP
  - SMOS
- Focus on SMOS





# History

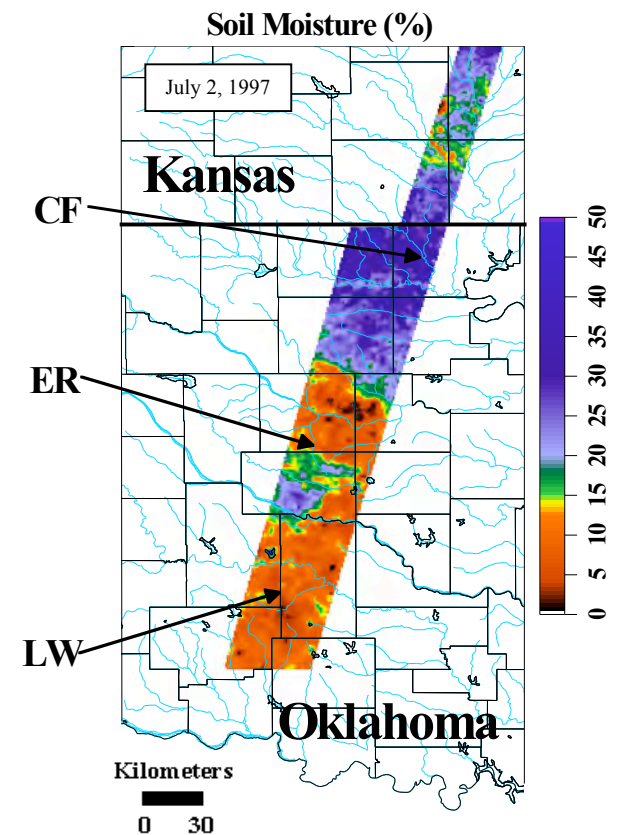
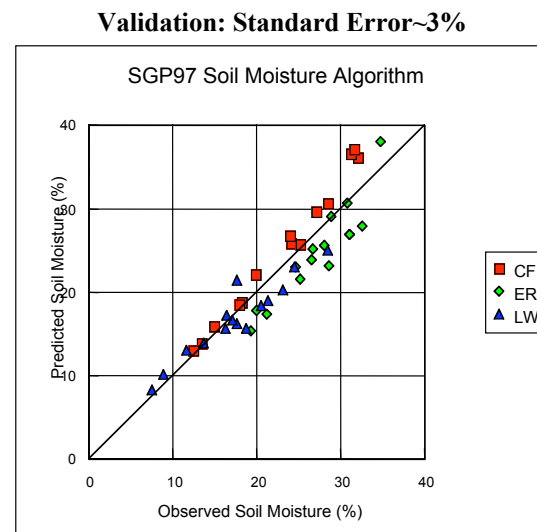
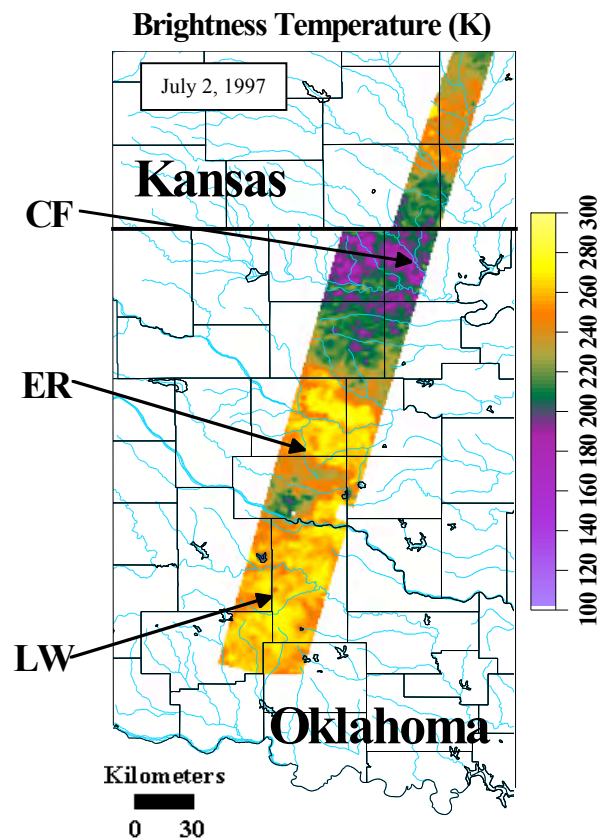
- Antenna size issue
- VLA, VLBI
- In the US the ESTAR concept (Swift, Tanner, Ruf, Levine)







# Soil Moisture Mapping and Single Channel Algorithm Validation Using ESTAR in SGP97



Yhk-2008

Microwave RS for Land Hydrology –  
Oxnard Ca USA

Jackson et al., 1999



# History

- Antenna size issue
- VLA, VLBI
- In the US the ESTAR concept (Swift, Tanner, Ruf, Levine)
- International Brainstorming at TUD
- Start of the SMOS concept called MIRAS





# The interferometry Quest







# Inception of the SMOS concept

## International Brainstorming

- Many option!
- Back to basics (and to Toulouse) 1990-91
  - A. Lannes suggests to revisit the VLA concept
  - JP Goutoule looks at instrumentation
  - YK looks at the use (science specs)
- → 2D concept
- In the US
  - US 1D instrument (ESTAR → Hydrostar) or
  - real aperture antenna (→ ISIS – OSIRIS or even Aquarius)
- But close contacts through « co-PI ship ». Issue of « no exchange of Funds » principle.
- Frequent exchanges at Science and instrument level
- ESA picks up the challenging mission through French funding.



# The dark ages

- Smos Development goes on
- Strong skepticism from decision makers
- France stops funding MIRAS through ESA
- All technology and know how is transferred to Spain who now sponsors the project
- Many proposal to NASA, ESA, Russia, .. to no avail though the first airborne MIRAS is built in Toulouse and ESTAR proves the point



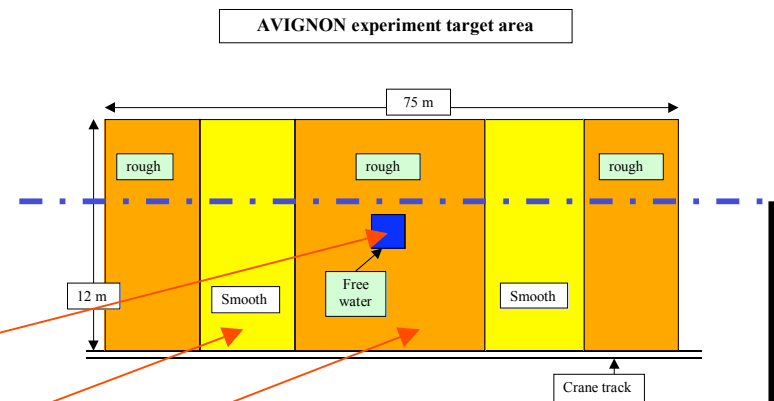
# SMOS

- Field experiment in Avignon with MIRAS Demonstrator (3/99)
- Measurements over bare soil with varying roughness and moisture.

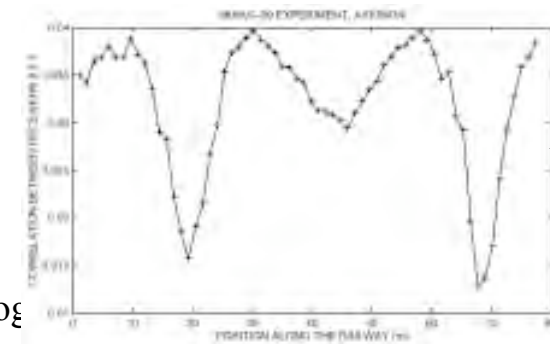


MIRAS DEMONSTRATOR ↑

Experimental set up ↓



Measured profile along a line (in blue) →



Yhk-2008

Microwave RS for Land Hydrology  
Oxnard Ca USA





# New Hopes

- 1997 SMOS concept is accepted by CNES
  - But not fully funded!
- 1998 new round of calls for proposals
  - Failures at ESSP
  - SMOS selected by ESA → becomes fully European  
ESA lead with CNES and with a special status for Spain.
- Negotiations with USA
  - Dilemma
    - What is needed is not what can be exchanged
    - My will to keep it simple and feasible (avoid MIRAS failure)
    - NASA will to provide something more science related than a launcher
  - Collaboration fails at Agency level
  - But Scientific cooperations goes strongly!



# Science Objectives for *SMOS*: The *SMOS* Mission

SMOS is the second Earth Explorer opportunity mission (1st round)

An **ESA/CNES/CDTI** project  
Selected in 1999, initiated in 2000

Phase B and C/D finished,  
instrument ready for launch  
(June 08) for a launch in 2009

A **new technique** (2D interferometry) to provide **global measurements** from space of **key variables** (SSS and SM) for the **first time**.

- **Need** for soil moisture and sea surface salinity fields
- **Only** passive L band suitable
- Real aperture systems currently not adequate (antenna size)  
==> Synthetic antenna





# Science Objectives for *SMOS*: The *SMOS* Mission

## Mission specifications

**Soil Moisture**

multi-angular

dual pol

4 % vol 3 day revisit

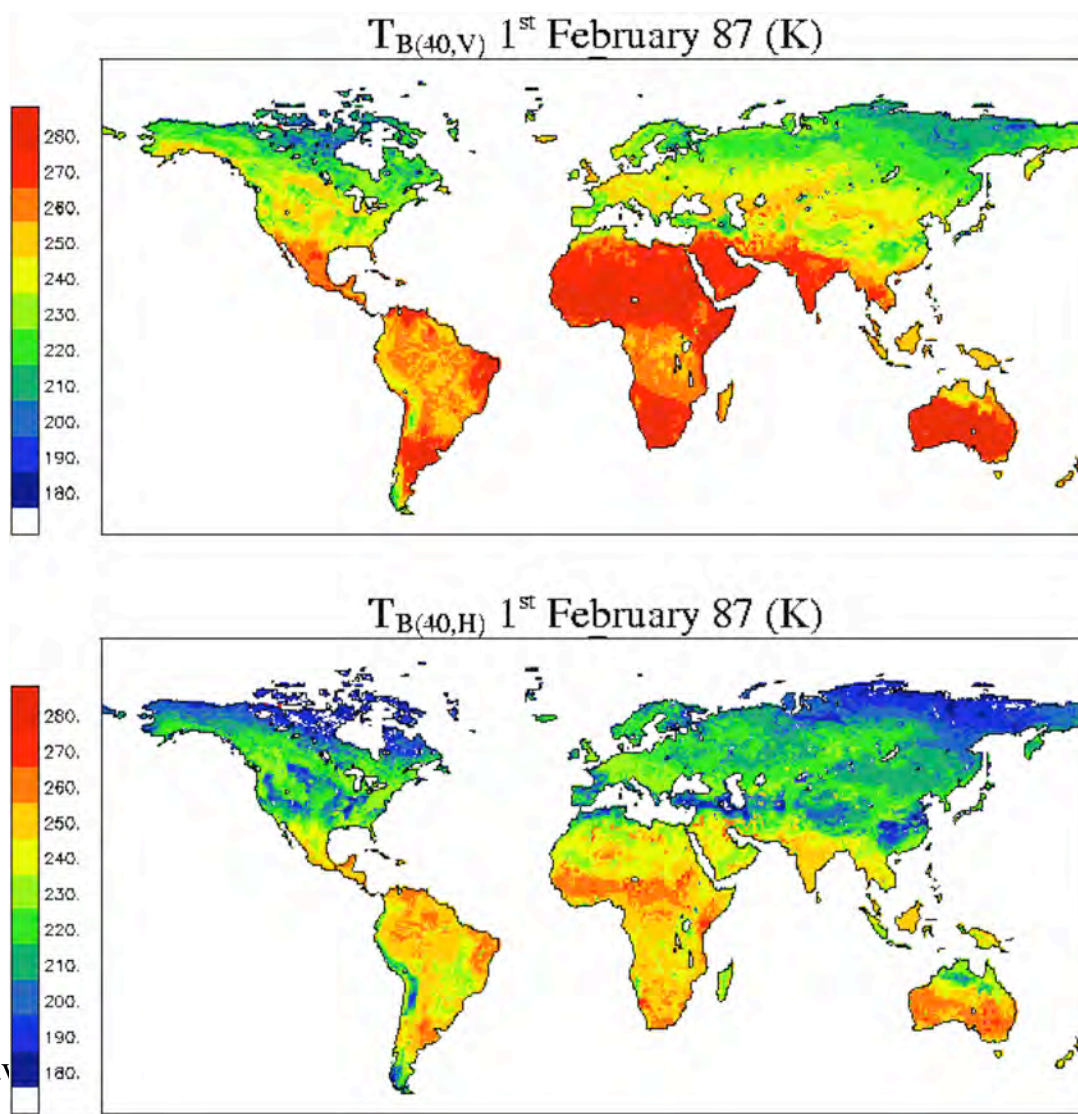
(Vegetation 7 day)

better than 50 km

Pellarin et al

Yhk-2008

Microwav







# Science Objectives for SMOS: The SMOS Mission

## Mission specifications

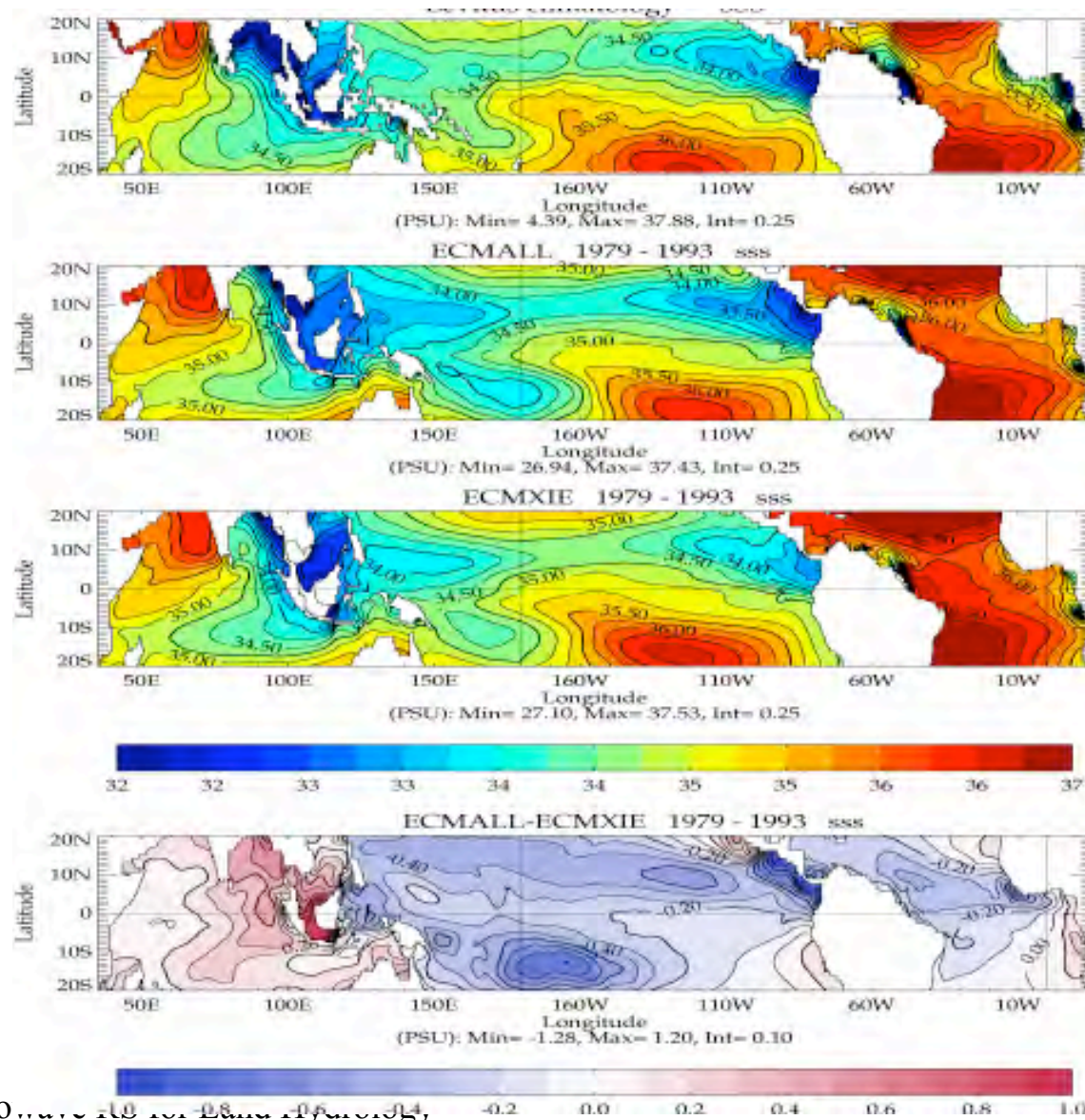
### Sea Surface Salinity

multi acquisitions  
dual pol or 1st stokes  
better than 0.1 psu  
10 day to monthly  
Grid scale (200 km)

Le Traon et al

Yhk-2008

Micro wave for Earth Remote Sensing  
Oxnard Ca USA





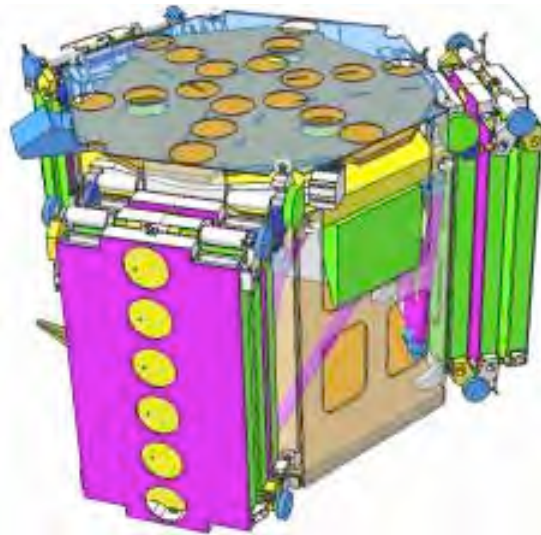


# A slow start

- CRYOSAT
- Funding profiles
- ESA bilateral agreements (SPAIN and CNES)
- Difficulties with the PI concept at ESA
- ESA geo return rules, PB-EO and other DOSTAG stories
- But a good start nevertheless
  - Good interactions with US scientists
  - SMOS is truly international (Japan, China, India, Australia, etc.. Are getting involved one way or another)



**Payload Module** (deployed)



**Payload Module** (stowed)

**SMOS Instrument:** MIRAS derived concept  
CASA EADS (Spain)

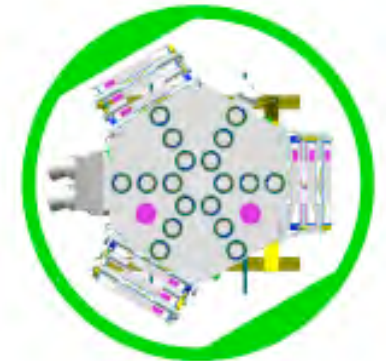
**BUS:** PROTEUS  
Thalès Alenia Space

**Launcher** ROCKOT

**Ground segment:** Level 0-2 Villafranca  
Level 3-4 Toulouse



**SMOS in Rockot**



CASA EADS, 2003

for Land Hydrology –  
rd Ca USA



# General evolution 2000 - now

- New start in the US (Aquarius Hydros)
- Still good science collaboration
- On several occasions turmoil in France/Europe where SMOS is twice in big danger of being stopped.
- The SMOS Project plods along never the less
- No visible coordination at Agencies level
- ECMWF, Eumetsat, various met centres show strong interest (NRT)
- Hydros Cancelled
- And then
- SMAP is born



# Where are we?

- SMOS ready to be launched
- Aquarius close to be launched
- New start of Hydros through SMAP
- Start of SMOS Ops
- International science collaboration, Cal Val exercise
- Very strong European Cooperation
- China joins the band wagon

BUT

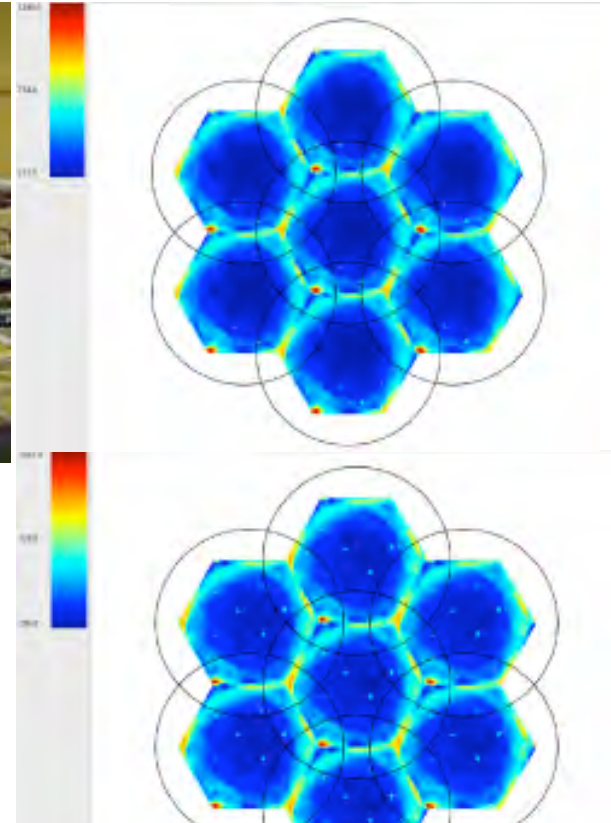
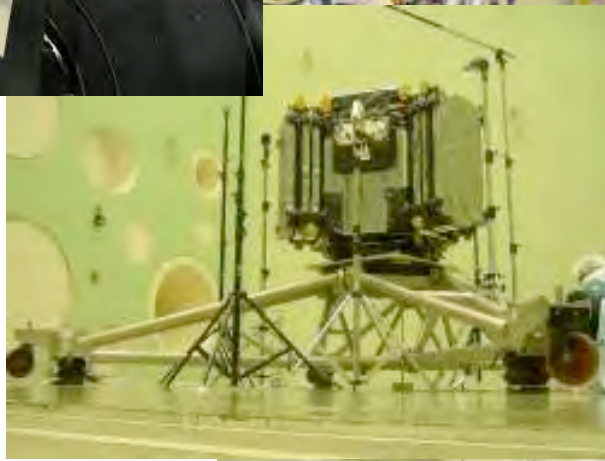
- Still no obvious coordination at Agencies Level



# SMOS Project status

- **Instrument → delivered, mated on PROTEUS platform in 06/07**
- **Satellite ready (June 08) and Rockot Launch → 2009**
- **Ground segment Level 0-2 almost done and level 3-4 initiated**
- **Cal Val AO Science AO released and groups selected**
- **International Campaigns (SMOS REX, Eurostarrs, COSMOS, NAFE, AMMA)**
- **International Cal/Val**
- **Algorithm development (France, Spain, UK, Germany, Canada,...)**





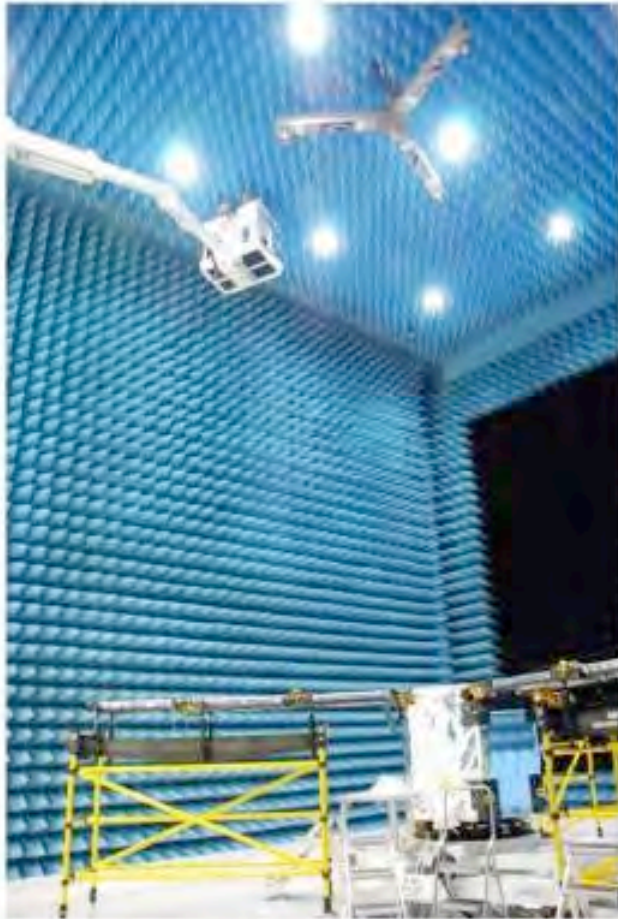
Ynk-2008



col

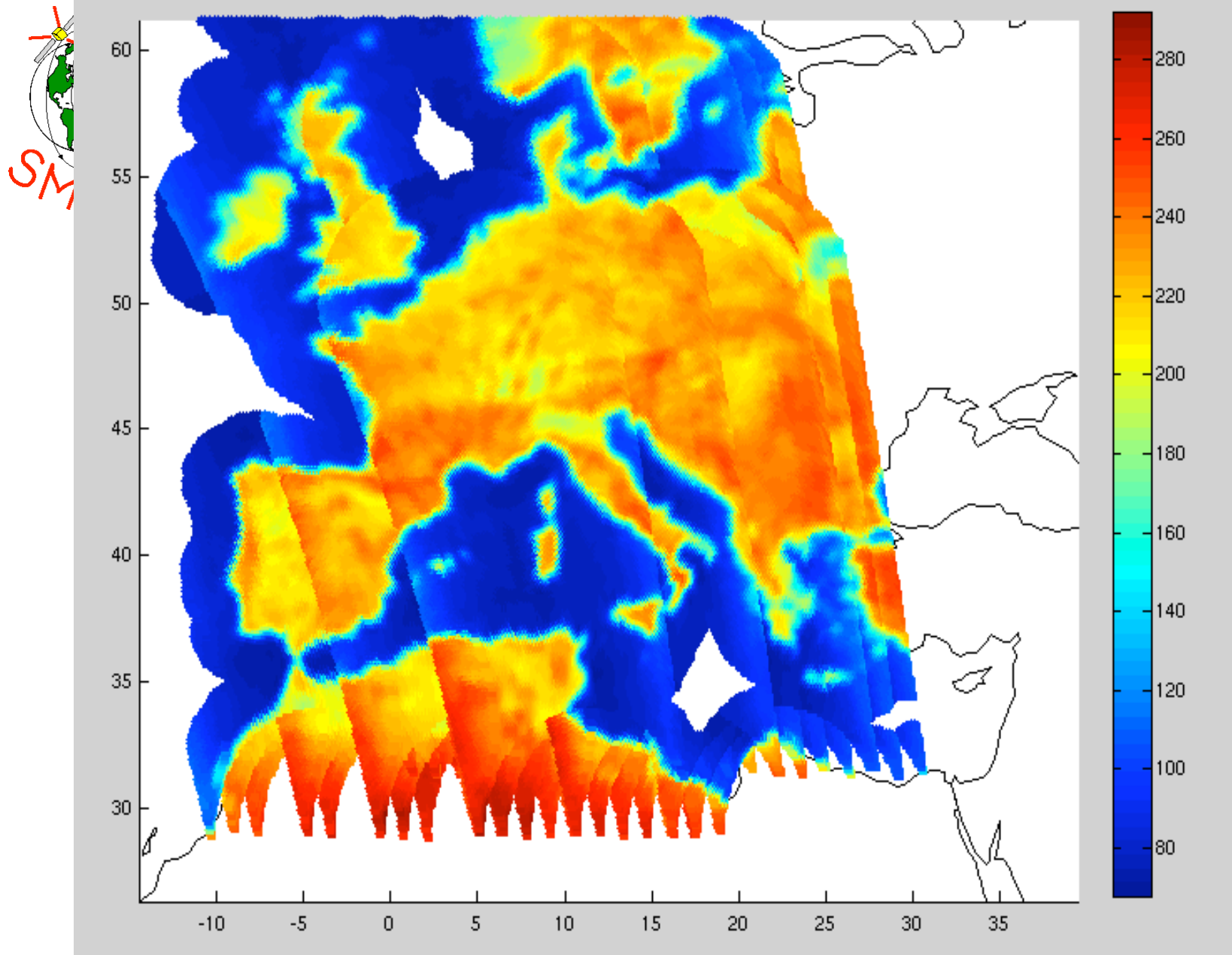






IVT / EMC





Yhk-2008

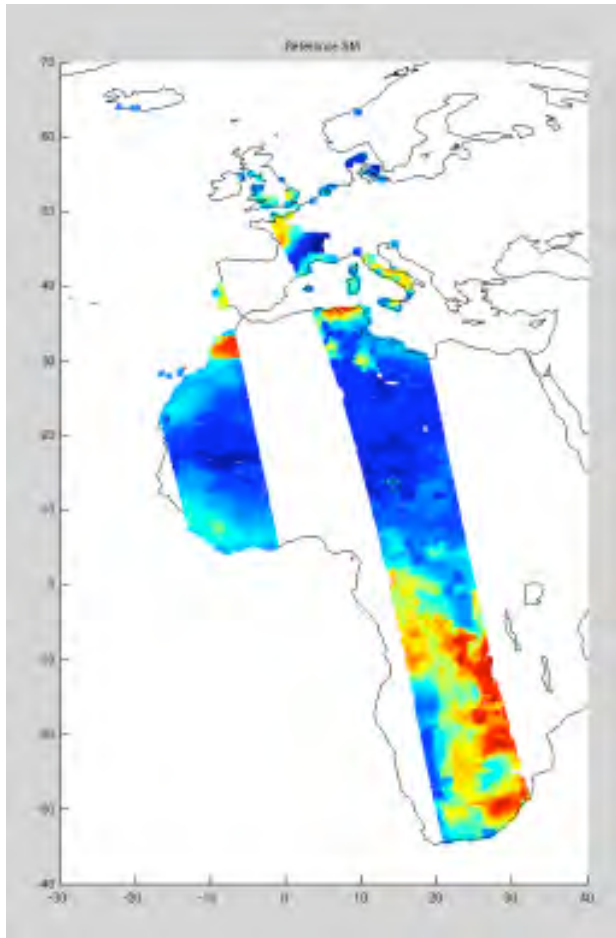
Microwave RS for Land Hydrology –  
Oxnard Ca USA



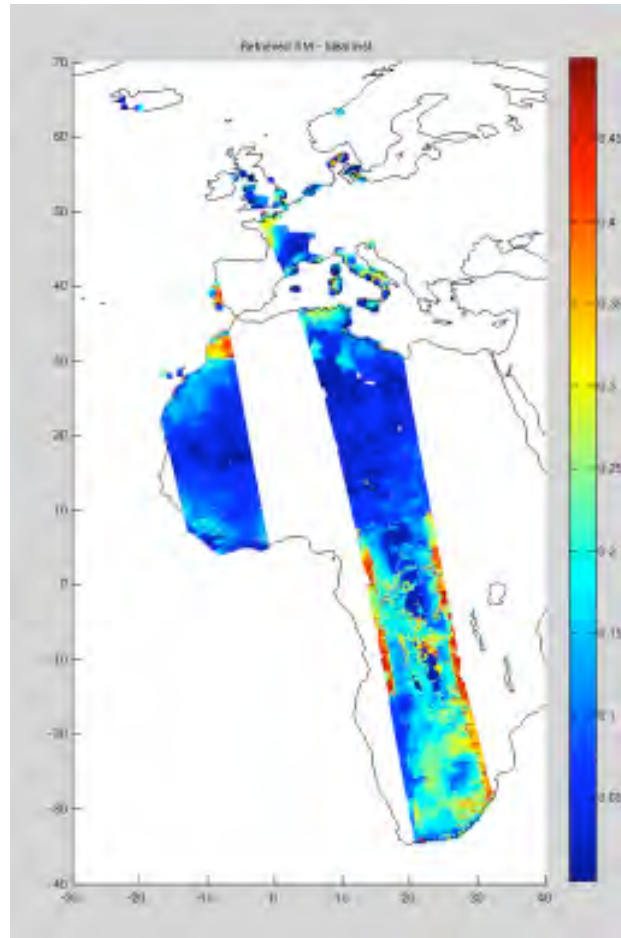


F Cabot et al

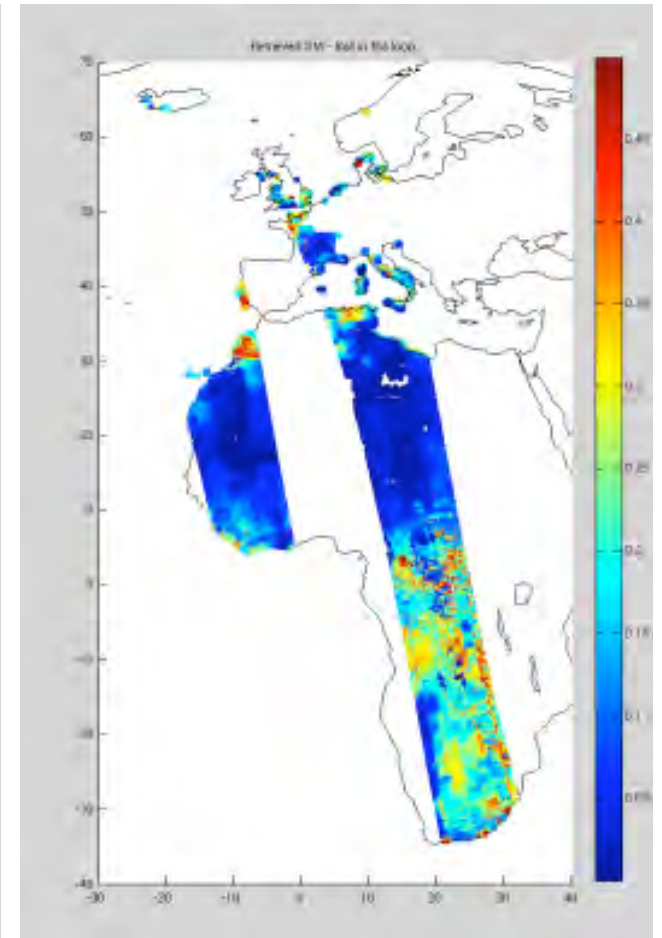
# Results – L2SM



Yhk-2008



Microwave RS for Land Hydrology –  
Oxnard Ca USA





# Conclusion

- **SMOS** will be the **first mission** to deliver global fields of **soil moisture** and sea surface salinity
- **The challenge** → NO data exists, NO Algorithm exists: we are breaking new grounds
- Launch date → **SMOS 2009** - tomorrow!
- Payload and Bus finished and tested
- Fruit of an international collaboration
- But still several hurdles and issues to be solved
  - RFI, heterogeneity, SSS, ...
- Soon to be followed by Aquarius, SMAP, SMOS-OPS?



# The soil moisture and sea surface salinity quest

- Fruit of all the previous studies and research which lead the way towards the SMOS Aquarius, SMAP concepts
- All the team indebted to the “precursors”



A satellite with a yellow body and multiple blue solar panels is shown in orbit against the backdrop of Earth's blue and white clouds. The satellite is oriented diagonally across the frame.

<http://www.cesbio.ups-tlse.fr/us/indexsmos.html>

**Thank you!**

**Any questions ?**